DoD's Technological Edge

Zachary Lemnios, Director, Defense Research and Engineering

We need to find ways to innovate early concepts in the field as opposed to innovating them and refining them in a research lab and giving [warfighters] a final product.

Zachary Lemnios is the military's top science and technology executive, responsible for about $12 billion worth of Department of Defense science and technology programs. For years, Lemnios helped spearhead the military's advanced research into turbo-powered microelectronics, labs-on-chips, and learning machines. Now, as the current director for Defense Research and Engineering (DDR&E), he is determined to get the best technology into the hands of the warfighter today while keeping an eye on what technologies will matter in 10 years. *Defense AT&L* spoke with Mr. Lemnios in late December about his vision and trajectory for DDR&E.

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Can you begin by talking a little bit about your roles and duties in your job as DDR&E, which also makes you the DoD chief technology officer. Can you give us an idea of what your roles and responsibilities entitle?

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My title is the director of Defense Research and Engineering, and in that capacity, I report to Dr. Ashton Carter [*the under secretary of defense for acquisition, technology and logistics*]. I have responsibility for the department's full scope of science and technology efforts, to include the work within the Services and within the Service laboratories, the internal science and technology investments that we have within DDR&E.

In a sort of traditional chief of technology role, I have responsibility for a broad scope of activities and work with the Services to shape those in concert with their needs and their activities within their departments. I work closely with the Service organizations and tightly with the Service laboratories. It really is a strong engagement across the whole scope of peers within the department.

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You assumed this role in July 2009. Upon your arrival, you introduced four imperatives as the focus for DDR&E. Can you briefly describe the imperatives for us?

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Let me start by saying a little bit about my background, which might set some context. This is actually my third tour in the department. I was previously, on two occasions, at DARPA [*Defense Advanced Research Projects Agency*], first as a program manager, and then running two of the offices at DARPA: the Microsystems Technology Office and the Information Processing Technology Office. So this is my third time here. It was a bit of a surprise, but when I got the call, I quickly said yes and came aboard. I rejoined the department on July 2, departing MIT Lincoln Laboratory. My background really is at the intersection of technology and systems, trying to build new capabilities that enable new system concepts. And in that capacity, I was absolutely delighted with the opportunity to come on board and shape the larger perspective for the department.

In doing that, I was able to meet with a number of the former DDR&E directors, and I met with many people from across the department and outside the department and elsewhere in government as I was preparing for my confirmation hearing. It was readily apparent that we needed to put a few things in place very rapidly, and that is really what drove the four imperatives.

Let me spend a few minutes talking about those. I call them imperatives because they are not lofty goals or broad mission statements; they really are where we are putting our resources and our time and effort into day to day. The first of those is probably the most important, and that is to rapidly transition technical capabilities from our research and engineering enterprise to the warfighter. We need to do that in a matter of weeks and months, not years and decades, and move concepts from research and engineering into the warfighters' hands so they can use them. This involves interaction with the combatant commanders, and this involves a tight understanding of what is needed with our users in the field. It involves a keen understanding of what concepts are available that are being developed in the research community. We spend a lot of time working with both the research community and the end users to make that happen.

The second imperative is also important and is really a sort of classic DDR&E mission: to invest in concepts and technologies that will be the core capabilities for the nation five, 10, 15 years from now. It is really investing for an uncertain future. It is investing in people and ideas that will be as groundbreaking a dozen years from now as GPS, stealth, or precision guidance have been over the last decade. Certainly with our efforts at DARPA, which is part of DDR&E, and elsewhere across the department, we are making large investments in advanced technologies such as quantum science, advanced information systems, advanced sending, human and social behavioral models, and a variety of concepts that a decade from now will really be at the forefront of many of the system concepts that the department will be needing. That is really the traditional mission for DDR&E.

The third imperative is one that Congress and the president helped us with by enacting the Weapons System Acquisition Reform Act of 2009. The third imperative is to reduce the acquisition time, the risk, and the cost for major defense systems. Through the Weapons System Acquisition Reform Act, it is absolutely apparent that we need to find more effective ways to build our very complex weapons systems. For us within DDR&E, we've taken that on by standing up the Systems Engineering Directorate and the Developmental Test and Evaluation Directorate. Those two directorates really form the underpinning for the whole set of efforts that work with program offices within the department and the contractors to both understand the risk and embed systems engineering into system concepts that are being developed for the department.

The fourth imperative is one that I felt was foundational. It was something we just had to take on, and that was the science, technology, engineering, and math initiative, which will lay the foundation for future scientists and engineers that will be in the department.

So those are the four initiatives, and they kind of center the work that we are doing in DDR&E and many of our investments.

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You've stated that one of your major challenges is to preserve the technological edge of the current force by extending the capabilities of our warfighting systems by incorporating better intelligence, greater speed, longer range, higher precision, and more effectiveness. Can you share with our readers examples of how and where this is being done?

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We absolutely are concerned about extending our capability set, and I want to talk about that in two areas. The first is taking concepts that currently exist, and the second is investing in new concepts.

With regard to concepts that currently exist, we have a Rapid Fielding Office that is looking at, through our open business cell and through other activities within that office, exploring existing capabilities that are in the commercial sector and exist within the industrial base and that can be applied to issues that come in from our combatant commanders.

I should say that when I came on board, I made it a priority to meet with each of the combatant commanders. There are 10; to date, I've met with eight, and I will meet with the last two over the course of the next month or so. Through those discussions, I've learned not only what comes into the building in terms of urgent operational needs or joint operational urgent needs, but I've also understood what concerns are on the horizon that these combatant commanders really care about. We can and we have resourced solutions for many of the joint urgent operational needs statements through our Rapid Fielding Office.

But we are also looking at what the future will bring and what the future requirements will be. And so we are making investments in our Science and Technology (S&T) Office to really understand what those things will look like. This is driven by studies we have put together, very rapid studies that kind of give us a lay of the land. We launched one very early on the future of computer science. We launched another one in network security. We launched a third study in electronic warfare. That one was interesting because it looked not only at electronic warfare challenges that exist today but where the private sector is going with commercial technology, how that will impact the way we build electronic warfare systems, and how our adversaries are going to build them. We've really taken this red/blue, measure/counter-measure assessment to try to understand, as we build concepts, how will our adversary counter them and how will we counter our adversaries' concept. Most of the projects that we take on are sort of like pick-up games—we find the right resources and the right people within DDR&E. We bring people in from other agencies and other parts of the department, and we focus on a technical problem. In the case of electronic warfare, we engaged folks from the Naval Research Laboratory, from DARPA, and from elsewhere within DDR&E to try to look at that challenge and bring ideas to the table, and then we use the results of that study to impact our program guidance.

We have to have a balance between the deliberative processes that are needed for very large systems and the very agile processes that are needed to support requirements such as when someone's life is in jeopardy.

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You touched on how you draw on different minds to come up with new concepts. How do you encourage creativity and innovation within the DoD system?

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I think that is an absolutely central issue here. In fact, the coordinates that I think most about are the coordinates of innovation, speed, and agility. That is the coordinate system of any strong business. It is the coordinate system of any first-rate entrepreneurial organi-

zation. But they are not the traditional coordinates of the department, and it is something we are trying to move toward. One way to move in that direction is to engage universities, to engage small businesses, and to engage research organizations within large businesses; and we do a lot of that. I spend a lot of time meeting with each of those organizations. I encourage them to come in and tell us how they have new ideas and how they can bring on new concepts very rapidly.

But again, all of this drives toward the need to rapidly deploy new concepts within weeks and months. That is something that we have to do at a very high pace for quite some time.

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Can you discuss the organization of DDR&E?

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DDR&E had a large number of offices, all of which were doing good things with good, dedicated people, but I wanted to really cement an organization that reflected the imperatives we had put in place. In doing that, we stood up the Research Directorate, which is largely centered on the S&T objective. We stood up the Rapid Fielding Office, which is all about getting concepts quickly to the field. We stood up the Systems Engineering Directorate and the Developmental Test and Evaluation Directorate, and those two are really structured around our major weapons system programs.

In all cases, we brought in some very, very good people, and we've coupled very tightly with organizations outside of DDR&E across the department with the Service laboratories to make this happen.

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Was this restructuring also designed to create an organization that would reduce the cost, acquisition time, and risk of major defense systems?

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Absolutely, and let me give you an example of that. Our Systems Engineering Directorate has two functions. The first is to help the program offices understand what the risks are in major weapons systems, what the technology readiness assessments are, how mature are the technologies that are going into these systems, how mature is the manufacturing capability of the contractors that are building the system for the department, and what the test results are from early article evaluations from those systems.

But the other side of the Systems Engineering Directorate is something that we stood up and I wanted to really drive hard: an organization that looks at systems architecture very early in the program, well before we have a program of record. They really look at the system trades, the architectural trades, in system concepts. Much of the cost of a major weapons system is determined well before Milestone A, well before we even launch the program in a major way, when we set the architecture. It is sort of like building a house: you can get an architect to design a house for you, and you can always pay for changes later, but if you get the architecture right first, you will save much of the cost later on the cost of your home. We do the same in building a major weapons system. Much of that cost is determined by the early architectural understanding.

Having an activity here that really understands that trade space—how we bring systems together, what is the performance cost trade space of an architecture relative to another architecture—that is a discipline that the department had 20 years ago and it has since atrophied for a lot of reasons. We are trying to rebuild that. That activity resides in our Systems Engineering Directorate. And I think that activity is going to have significant benefit to future systems concepts in the department.

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You also mentioned that there was a Developmental Test and Evaluation Directorate that was created. Can you talk a little more about the roles and responsibilities of this directorate?

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The Developmental Test and Evaluation Directorate is evaluating early system test results well ahead of Operational Test and Evaluation Directorate. As systems are being developed and the first articles go through testing, this directorate validates those results and works with the program office to make sure the test plans support the needs of the system and are independently verified. It provides an assessment of the risk for that program to move to the next step. It is really part of our much broader set of activities that we have with all the major systems programs to really understand how they are proceeding along their major system program development.

I think you see a strong engagement between the developmental test and evaluation and the operational test and evaluation. The difference is operational test and evaluation is done with the final test article; developmental test and evaluation is done with an early article before it has finished its full development. What that does is help us assess risk in the program while the program is still under development. By getting early feedback of these test results, we can reduce a lot of risk in the system program process. It is a quality control function, but it is also providing feedback to the design group, and that is a critical feature. It is not an audit group. In fact, what I've encouraged all of our folks at DDR&E to think hard about and work hard at is we are not an audit function; we are thought leaders in each of these functions. The role of developmental test and evaluation is to understand the test results from early articles that are built and early system concepts that are demonstrated, and feed those results back to the developer so they can harden the design. It is that feedback loop that will help us quickly converge on system concepts that provide the performance that is really needed.

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Right now, DoD is shifting its focus from operations in Iraq to Afghanistan. How is DDR&E responding to those shifting requirements?

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That is an important shift, and it is one that is challenging our ability to field systems on a very rapid basis. It is challenging our ability to bring new technologies to the warfighter, and challenging our ability to really do this at pace. In anticipation of this, we stood up several task forces that are actively working to bring concepts to the field in the areas of base protection, helicopter survivability, and counter-IED. Those three are really at the forefront of what we are working on right now. We have other task forces working in other areas, but those three are really our focus, so let me spend a minute talking about those.

We stood up the Helicopter Survivability Task Force in the summer of 2009. It ran for about a month and came out with a number of early concepts that we could quickly bring to the fight and deploy by spring of 2010. We've been working with Army Aviation and folks across the building to find concepts that would protect our H-60 Blackhawk helicopters and our CH-47 Chinooks, the predominant helicopters in Afghanistan. As part of that recommendation, we also came up with a concept to use the autonomous helicopter A160 Airship for a resupply mission. In doing so, we would take airmen out of harm's way in a resupply mission. That is an autonomous helicopter, of which the department currently owns about 10 or 11, and we would use two of those in Afghanistan for this resupply mission. The Helicopter Survivability Task Force looked at what concepts we can bring to the fight in March/April 2010 that would significantly reduce the risk of our helicopter operations in Afghanistan. We identified the first round of concepts, then a second round that will be ready in September 2010, and a third round that will be ready in March 2011. Each of these requires increasing levels of development with some risk associated with the out-year activities.

The Base Protection Task Force is doing the same thing for how we protect our base operations on forward deployed bases. We've looked at everything from what we can do to reduce fuel usage and improve water supply activities at the forward bases, and what we can do to improve surveillance concepts and reduce the risk of an intrusion from unknown threats on these forward operating bases. We are just now working through those concepts, and we will be making some recommendations to the department in the next month or so as to what we can do there.

We are also working with the Counter-IED Senior Integration Group, in terms of technical concepts, to counter the IED threats that are occurring in Afghanistan. Those are very different than the IED threats that we've seen in Iraq; they are largely homemade explosives, the networks are far more complex, and they are far more disruptive. We are looking at what the future threat would look like, and how might we disrupt a number of networks as opposed to just a few networks, and those concepts are being considered by a group that we are supporting within DDR&E.

When I became director, I made it a priority to meet with all the combatant commanders, and they have all told me the same thing: We need the 80 percent solution today rather than the 100 percent solution five years from now.

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How are you balancing DoD rules and regulations about this issue and getting these products out quickly?

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We've always had a lane in the requirements process to support our joint urgent operational needs. We have needs statements that come in from the combatant commanders routinely for urgent operational needs where there is a need for a concept to protect life, where there is an imminent threat to life. Those needs are balanced across the department. They are resourced through Congress's reprogramming actions or within the department. We look at what concepts are available and work with the comptroller within the department to resource those, as well as with Congress, to start new activities when those make sense.

We have to have a balance between the deliberative processes that are needed for very large systems and the very agile processes that are needed to support requirements such as when someone's life is in jeopardy; we just can't rely on a five-year process to support the real-time, near-term needs of the department.

I mentioned that when I became director, I made it a priority to meet with all the combatant commanders, and to a person, they have all told me the same thing: We need the 80

percent solution today rather than the 100 percent solution five years from now. We need to find ways to innovate early concepts in the field as opposed to innovating them and refining them in a research lab and giving them a final product, and they want to find ways to better engage the user in the definition of the concepts. In all cases, we are trying to find ways to do that. The DoD 5000 process really was put in place for the development and deployment of major weapon acquisitions. In that light, it makes a lot of sense; there are checks and balances. You would never build an aircraft carrier without a deliberative process. You would never build a joint strike fighter without a very deliberative process to control costs and schedule and performance. But there are other things that need to be done in a much more rapid way, and through our Rapid Fielding Office, we are trying to do that.

We have a joint rapid acquisition cell. This group of very dedicated people works with the combatant commanders to identify the joint urgent operational needs, and they find ways to resource those needs very rapidly through existing contracting channels that we have through our contracting base. In some cases it may be a reprogramming action; in most cases, we will go to the Services to resource those.

You've got to have both these processes in place. You have to have a very rapid way to move concepts and you've got to have a very deliberative process for very large programs.

Innovation, speed, and agility are the coordinates we are trying to work through, and if we make those changes over the next several years, it will really have a positive impact for the department.

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In the last few years, DoD has focused on quickly procuring technologies to get them to the warfighter faster. As director, how do you foster communication between the technology communities, acquisition personnel, and end users to speed technology transition?

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That is a big challenge. We come back to that issue over and over again when speeding concepts to the field—understanding what is possible. I guess the first two parts of that challenge are understanding what the user really needs and understanding what is possible from the technology side. In many, many cases, what the user needs is more than just a single technical widget; it is a combination of some new technical concept, some new operational concept, and maybe something that integrates the two. I think we spend as much time on the user side of the equation as we do on the technical developer's side of the equation. And that is really an area that sets us apart. Organizations like DARPA spend a lot of time on the developmental side of the equation. They also have a tight connection with the user, but their real focus is in developing new technical concepts. I look at the Service research laboratories, and they are deeply steeped in technology development for core service missions. Our job is to try to integrate those with what the user really needs in terms of the system concept.

I've had discussions with the combatant commanders in terms of what are their challenge scenarios; what are their scenarios where they not only need a technical concept, but they need an evaluation of all of the component parts of the complex systems they employ

You hear a lot about compensation and salary and all that, but at the end of the day, my experience is that the people who take on the enormous challenges of national security do so because they can make a difference.

(an architectural evaluation), and we are trying to build that into our program plans as well. I think we will be doing more architectural trading where we examine the various alternatives and options to create an optimal solution for these systems. Our goal is to understand the architectural trades basis for what a combatant commander really needs in the field, along with their assessments to try to build a technical element.

I'll give you an example of how we are trying to drive the transition of technologies through the Joint Capability Technology Demonstration [*JCTD*] program. This program started probably 15 years ago as the Advanced Concept Technology Demonstration program, and at the time, it was a program really to field early concepts in about 18 months. It took off and developed all sorts of early demonstrators—the UAV [*unmanned aerial vehicle*] was one of its early programs.

But over time, that program morphed into larger and larger system concepts and longer and longer duration timelines. Most recently, it has taken on some very important projects but the timelines have moved very much to the right, so they are now four- or five-year programs. They don't have the level of innovation that I was really hoping they would have. So we took a really close look at this and we reshaped the JCTD program so that the first year will be an early demonstration. We are asking that we get the requirements in from the combatant commanders, and that they give us their rack and stack of what they want to pursue. Then we work with their folks to define the first-year demonstration and really work that first year to demonstrate the early concept. We'll use that demonstration to evaluate whether we move forward with the program.

Getting people focused on what that one-year demonstration will actually look like drives the innovation, drives the competitiveness of that program, and I think it is going to pay big dividends. We've gotten broad support across the spectrum on this.

Q *Looking at all of DoD's threats right now—cyber attacks, terrorist attacks—it is uncertain who the enemy of the future will be and how that enemy will engage. Identifying breakthrough capabilities can garner DoD significant advantages over potential adversaries. What does DDR&E do to identify the new or emerging technology that will provide an edge over unknown enemies?*

A We've put in place a strategic cell to do some of those assessments, and this includes strategic net assessments against concepts and technologies that we see both overseas and globally. Those assessments are also helping us better focus our internal resources. I really want to make sure the S&T investments that we have within the department are all focused on the most pressing challenges the department faces, and that our investments are overwhelmingly competitive relative to what we see in the private sector, and certainly with our adversaries. Building assessments that evaluate the research that we are investing in relative to best-in-class in the private sector and best-in-class to what we've seen offshore is critically important, and we are doing that.

I think as far as the technical areas, the threats that we are seeing clearly have a much larger information content. The ability to disrupt our information networks is absolutely critical. We are working to protect them in a significant way.

We have significant investments and programs looking at how we build very complex systems. The complexity of our systems is a systems engineering challenge, and having the tools and the ability to integrate a large number of systems in a network sense is critically important. Most of what we are building now are network-enabled concepts, so understanding how you build reliability into that and how you build assurance of performance into a very complex system is a challenge that we are addressing.

Q *A recent study observed that "civilian career paths in the DoD research labs and program management are not competitive to other opportunities in attracting outstanding young scientists and retaining the best people." What plans*

does DDR&E have to attract needed employees from the STEM career fields: science, technology, engineering, and mathematics?

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We spend a lot of time talking with students, with people in those areas across the base. We have tight connections with industry and academia. I think a lot of it is done by example. I think if you give people a challenging problem, give them the resources to work through that challenging problem, and give them the right environment where they can grow technically and contribute, then people will move in that direction. You hear a lot about compensation and salary and all that, and that's great, but at the end of the day, my experience is that the people who take on the enormous challenges of national security do so because they can make a difference. They understand the importance of the programs they work on. I came from MIT Lincoln Laboratory, and certainly, we saw that people were there because they wanted to contribute to a national defense initiative. They had the resources, the environment, and the lab structure to really make it happen. While compensation was good, the most important thing was making a difference. And when I visit academia, when I visit industry, I see the same group in support.

We are working closely with the DoD laboratories to really make sure the infrastructure is correct. We are making sure we present a set of challenging problems for them to work on, and certainly we are doing that, but I am also trying to bring in some very good people within the department. Whether we bring people on board as DoD employees, or whether we engage our FFRDCs [*Federally Funded Research and Development Centers*], our UARCs [*University Affiliated Research Centers*], and other activities outside of the DoD to work on DoD problems, we'll work all of those channels. At the end of the day, the department has a very clear set of national security challenges before us, and we need very bright people to help us work through those, on the technical side and on the operational side. It is really that intersection that becomes very important.

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What is DDR&E's role in support of the recently published Quadrennial Defense Review (QDR) 2010?

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We've been very much part of the QDR. We've attended and, in fact, led many of the technology initiatives that led up to that, and we are certainly aligning our science and technology reviews to align with the QDR. We've led seven of the program objectives memorandum program budget assessments, including energy security, cyber security, medical research, space research, space architecture, and a number of other areas. We've led a number of the technology assessments—biometrics is one we had a key role in, having led much of that effort in Iraq and now standing up a biometrics effort in Afghanistan. For us, that was critical. And we are providing technology integration in support of the QDR initiatives. I think that is an important document; it will be the unifying element across the department for our defense posture.

Part of our role within DDR&E is not only to develop technology concepts but to look at how those concepts fit into a broader architecture. How do systems interoperate, how do the core technologies enable system concepts? Going from technology investments to system capabilities to operational capabilities, that thread is critically important, and we provided assistance to the QDR in working that thread—certainly in biometrics and other areas as well.

You can look at top-down requirements and look at the top-down missions assessments; these are the missions the department wants to pursue, these are the core capabilities that it needs to pursue the missions, these are the enabling technologies that are needed to support the capabilities. We do a lot of the top-down assessment. Much of what we do within DDR&E not only supports a top-down assessment but really thinks hard about where that technology could make a difference in the overall scheme of things. DARPA does that pretty well. They are not a requirements-driven organization at all; they were never designed to be that, and they shouldn't be. They really start with a core technology and think about what capabilities that technology could provide the warfighter. We integrate those aspects and provide that integration function within DDR&E.

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Is there anything else you would like to add?

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I think the key message goes back to the four imperatives we put in place. I want to find ways to rapidly accelerate technology. We've got to make investments in people and ideas that will change the shape of our tool set and our capabilities a dozen years from now. The cost of weapons systems is enormous, and we are trying to make some big changes in our understanding of those systems. We've got to bring more really bright people into the department and make sure we have a future corps of scientists and engineers for the department.

In all cases, innovation, speed, and agility are the coordinates we are trying to work through, and if we make those changes over the next several years, it will really have a positive impact for the department.

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Thank you very much for your time, Mr. Lemnios.